COMPARATIVE ANALYSIS OF SECONDARY SCHOOL STUDENTS' ATTITUDES TOWARDS SCIENCE AND ITS LEARNING: THE SINGAPORE EXPERIENCE BASED UPON GENDER, ACADEMIC LEVELS AND STREAMS DIFFERENCES

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ABSTRACT

Students' normative perceptions of the nature of Science and their worldviews on the relevance of Science in pragmatic everyday contexts influence their keenness in wanting to learn Science and develop scientific mindsets. The chief goal of the research study delineated in this paper was to examine patterns of commonalities and variations in the attitudes of students enrolled in Singapore secondary schools towards Science as an organized disciplinary field of knowledge and the efficacy of the teaching of Science subjects in the classrooms. A constructed survey was administered as the primary means of data collection and statistical methods were used to analyze the collected data corpus to establish salient research findings. Generally students found Science to be of utility in making better sense of sensory experiences and understanding the complexities of the mechanistic functioning of this universe. Students were also generally satisfied with the quality of teaching being carried out in their classrooms. However, interestingly, gender, academic levels and streams based differences did emerge in scrutinizing students' responses on their conceptions of the structural character of Science and the approaches adopted in the pedagogical delivery of Science content matter during lesson time.

Keywords: Student Attitudes, Perception of Science, Science Education, Comparative Studies.

INTRODUCTION

An analysis of the major aims of science education reveals that an important dimension of the development of scientific literacy includes the development of positive attitudes toward science (Lederman, 1992; Linn, 1992). Students have to experience and appreciate the richness and beauty of knowing about and understanding scientific phenomena in the natural world. It is important to encourage students from an early age to imbibe favourable perceptions of Science, its learning and utility. Hence, the development of positive attitudes toward science is a critical component of science instruction planning (Gardner, 1991).

Research evidence points towards the fact that attitudes associated with the field of Science impact student participation in Science as an academic subject and object of experimental inquiry (Koballa, Crawley, & Shrigley, 1990). Such attitudes at a fundamental level affect students performance in science and related standardized tests

(Linn, 1992). Positive attitudes towards Science education results in improved learning achievements amongst students.

Numerous international studies have been conducted to comparatively gauge the views of students from a number of different countries on the epistemic nature and learning of Science as a disciplinary domain of knowledge. Such macro level analysis of global trends, though helpful, doesn't necessarily provide a nuanced and in-depth understanding of the systemic patterns of commonalities and variations amongst students' expectations of Science within localized contexts. Particularly, there has been a dearth of studies in relation to Singapore's educational milieu on the attitudinal opinions of students towards Science's pedagogical worth and pragmatic usefulness. The main intended aim of this research study was to fill in this gap through the dissemination of its empirical findings derived from the extensive investigation of Singapore secondary level students enrolled across different academic streams on their perspectives of Science and their interests in wanting to engage in pursuits of Scientific discovery.

Literature Review

It has been observed that many science students are able to apply algorithms in the classroom without deeper conceptual understandings of the content matter being studied (Nakhleh,1993). Some of the reasons attributed to the lack of conceptual understandings of science on the part of students to: novice learners who are adept with rote learning of arbitrary facts and generalized algorithms, students who perceive their teachers to be authoritarian and learn not to question their knowledge expertise curricula that inhibit critical thinking and finally instructors who emphasize algorithmic learning over conceptual learning (Pushkin, 1998). Piaget's assimilation and accommodation theories play an important role in comprehending how conceptual knowledge construction and integration takes place. According to Piaget, knowledge creation is a combination of prior experiences and innate intuition. Piagetian epistemology posits that knowledge generation as a heuristics-based process is personal, socially mediated, subjective, situated and an outgrowth of previous educational experiences.

Research in science education reveal that often the teaching that occurs in science classrooms tends to be the antithesis of Piagetian principles. The instructional strategies adopted by these teachers do not actively contribute to deeper conceptual understanding of science knowledge (Chiapetta & Koballa, 2005). Students who learn by rote learning accumulate isolated concepts separated from situated contexts rather than develop organized frameworks of inclusive concepts (Mintzes, Wandersee, & Novak, 2000). Meaningful learning is said to occur when the learner consciously chooses to integrate new knowledge within existing knowledge schema representations (Novak, 2002). Meaningful learning in Science classrooms can be activated through several effective instructional strategies. Classroom conversations between teachers and students and amongst students themselves is particularly important in solving higher order problems and cultivating critical thinking mindsets. Conversation is the essential dialogic process by which learners create and negotiate shared contexts of knowledge generation (Roeheler & Cantlon, 1997).

The teacher's role in facilitating this paradigmatic shift in pedagogical approaches cannot be over-emphasized. Teachers should help to restructure the cognitive structures of students through effective instructional techniques (Mintzes, Wandersee, & Novak, 2000). The teacher needs to present learning activities that serve as discrepant events in fostering knowledge construction through realizing the gap in knowledge expertise and the need to fill the gap with new knowledge accumulation. Concurrently, the student's role also needs to be re-examined. Since knowledge transmission cannot directly be imparted from teachers or textbooks, students needs to exercise intentional efforts in knowledge construction. Students must feel an intrinsic motivation to learn the science content for meaningful learning to happen (Gunstone & Mitchell, 1998). The students' inner psyche influences their desire to evaluate pre-existing cognitive schemas and modify them when confronted with a conceptual conflict to be resolved. This is crucial since students need to negotiate and create shared meanings of facts, concepts, laws, principles, generalizations and models associated with science. Science knowledge like other forms of knowledge is dynamic rather than static. Such knowledge is constantly evolving and so needs to be re-assessed and re-constructed by students. Students ought to be encouraged to view Science as subjective, coherent and transparent (Mintzes, Wandersee, & Novak, 2000). The role of textbooks as a curriculum guide is yet another key aspect of instructional planning that needs to be analysed in enhancing the quality of learning to be more meaningful. Anecdotal evidence indicates that high school teachers usually more or less follow the given standard science textbooks. Textbooks help to organize information, stress important concepts and set goals for the systematic study of a science phenomena (Trowbridge, Bybee & Powell, 2004). On the other hand, the organization of topics in textbooks requires that the students learn broader topics, before details of new and unfamiliar topics can be appropriately understood (Ausubel, 2000).

Numerous comparative studies have been done in analyzing studies perceptions of and attitudes towards science as a disciplinary field and educational domain. Relevance of Science Education (ROSE) was an international comparative study that investigates the diversity of interests, experiences and priorities that students from different countries bring to school or have developed at school. The underlying hope is to stimulate an informed discussion on how to make science education more relevant and meaningful to students. The ROSE instrument has around 250 single items on a 4-point Likert scale and about 40 000 students from 35 countries took part in ROSE. Students in all countries generally share a positive view of many aspects of the role of Science in society. However, there are large differences between students in different parts of the world on their attitudes towards science. Students in developing countries like school science very much, whereas students in richer parts of the world are more negative. Girls dislike school science more strongly than do boys (Schreiner, 2006; Schreiner & Sjoberg, 2004).

Trends in International Mathematics and Science Study (TIMMS) is another international comparative study that presents the science achievement results for fourth- and eighth-grade students from 49 countries and provides a rich array of information about the educational context for learning science (Martin, Mullis, Gonzalez & Chrostowski, 2004). The U.S. was one of eight countries that demonstrated a major increase in science in comparing performance from 1995 to 2003. It was found that Science teachers have made great improvements in the way they teach students, and the TIMSS study has substantiated progress in student achievement. Improved instructional practices, teacher qualifications and improved curriculum standards have contributed to the positive jump. Generally, students from developed countries such as the US, Japan and Singapore consistently outperformed their peers from developing countries. Though in the first 1995 studies boys did much better than girls by a substantive margin, over the years girls have shown significant improvement over boys in nine countries.

Research Methodology

A Questionnaire was developed to be administered to students to gather necessary data for statistical analysis. Questionnaires were chosen as the chief method of data collection since they have a larger reach in obtaining the responses of a wide number of subjects in diverse locations. This ensures that there is a better representation of target population and increases both the reliability and validity of the research undertaken. Other advantages of questionnaires include lesser costs, capacity to perform rigorous mathematical calculations and the flexibility afforded in respondents being free to reply at their own time and pace. The questionnaire focused its queries on students' attitudes, perceptions and other similar attributes on science and related educational practices *instead of achievement.* The survey instrument consisted of twenty-nine items of a variety of measurement formats. Most of the items were constructed on Likert scales with some requiring students to rank or circle applicable options. The sample size for this study was about 3200 Secondary school students in Singapore and drawn from the express, normal academic and normal technical streams.

Data Analysis

Statistical analysis involving descriptive statistics and ANOVA computations were performed on the data set to organize and interpret the data to gain better insights into attitudinal patterns of students towards Science as a disciplinary field and its learning. The following are the key research findings resultant from the data analysis that was carried out:

Teacher-centered teaching

ANOVA tests reveal that there is a significant difference in the teaching approaches applied in express, normal academic and normal technical classes ($F(2, 3253) = 12.304$, $p<0.05$). Post hoc tests inform that the extent of teacher-centeredness in instructional practices vary in the following order from the highest to the lowest: normal academic, express, normal technical (Table 1).

ANOVA tests indicate that there is a significant difference in the teaching strategies adopted in the secondary one, two, three and four classes ($F(3, 3252) = 11.108$, $p<0.05$).

Post hoc tests point out (smaller the means higher the teacher-centeredness in teaching) that

- the means of responses of secondary four students is higher than secondary one students
- the individual means of secondary three and four students are higher than secondary two students

Student-centered learning

ANOVA tests reveal that there is a significant difference in the learning practices of express, normal academic and normal technical classes ($F(2, 3223) = 13.502$, $p<0.05$) (Table 2). Post hoc tests inform that students perceive learning occurring in express classes to be less student-centric than in normal academic and technical classes.

Nature of Science

ANOVA tests show that there is a significant difference in the perceptions of students across the three streams (express, normal academic and normal technical) of the nature of science ($F(2, 3280) = 87.9$, $p<0.05$) (Table 3). Post hoc tests indicate that express students had more accurate views of the nature of science when compared with normal academic and normal technical students. Concurrently, normal academic students had more valid opinions on the nature of science than normal technical students.

ANOVA tests highlight that there is a significant difference in the perceptions of students across the four academic levels (secondary one, two, three and four) of the nature of science ($F(3, 3279) = 9.229$, $p<0.05$) (Table 3). Post hoc tests show that secondary one and two students had more acceptable perspectives on the nature of science than secondary four students.

Attitude towards Science

ANOVA tests highlight a significant difference in students' attitudes towards Science across the three academic streams ($F(2, 3234) = 42.067$, $p<0.05$). Post hoc tests show that the attitudes displayed towards Science across the three streams were in the following scale of order in terms of positiveness with express students showing the most favourable attitudes towards Science: Express, Normal Academic and Normal Technical (Table 4).

ANOVA tests reveal that there is a significant difference in students' attitudes across the four levels of academic study ($F(3, 3233) = 12.631$, $p<0.05$) with Secondary 1

	N	Mean	Std Deviation
Express	1980	11.32	2.66
Normal Academic	879	10.92	2.91
Normal Technical	397	11.73	3.39
Sec 1	1052	11.15	2.95
Sec 2	1025	11.02	2.89
Sec 3	847	11.43	2.69
Sec 4	332	11.98	2.48

Table 1. Teacher-centeredness

	N	Mean	Std Deviation
Express	1970	20.69	4.27
Normal Academic	865	21.61	4.70
Normal Technical	391	21.31	5.43
Sec 1	1032	21.39	4.79
Sec 2	1025	21.39	4.55
Sec 3	840	20.48	4.29
Sec 4	329	19.98	4.27

Table 2. Student-centeredness

	N	Mean	Std Deviation
Express	1987	5.87	1.01
Normal Academic	889	5.47	0.96
Normal Technical	407	5.25	0.87
Sec 1	1060	5.61	1.07
Sec 2	1041	5.63	1.05
Sec 3	852	5.74	1.08
Sec 4	330	5.92	1.06

Table 3. Nature of Science

	N	Mean	Std Deviation
Express	1980	15.06	2.85
Normal Academic	876	14.44	2.86
Normal Technical	381	13.69	3.04
Sec 1	1037	14.32	2.99
Sec 2	1027	14.78	2.90
Sec 3	845	14.96	2.83
Sec 4	328	15.26	2.73

Table 4. Attitude towards Science

students being least enthusiastic about Science and Secondary 4 students being most keen on Science. ANOVA tests also show significant gender-based differences in students' attitudes towards Science ($F(1, 3221) = 27.307, p<0.05$). Boys were more positive in their perception of Science than girls.

Dependency on textbook-based resources

ANOVA tests show that there is a significant difference in the dependence on textbooks by teachers for curricular delivery across the three streams (express, normal academic and normal technical) ($F(2, 3225) = 23.3, p<0.05$) (Table 5). Post hoc tests indicate that express teachers placed greater emphasis on textbook-based resources than normal academic and normal technical teachers.

Discussion

Teacher-centeredness of teaching

One set of items in the questionnaire examined the dimension of teacher-centeredness of instructional practices in schools in Singapore. In the traditional approach to teaching, most of formal curricular time is spent in didactic methods of instruction involving the teacher dominating classroom proceedings and students either passively watching or listening without their opinions being actively solicited. Students largely play a peripheral role during these pedagogical transactions and exercise little control in regulating their own learning performance. Students tend to work individually on assignments and collaborative synergies are discouraged. Student-centered teaching strategies shift the locus of learning activities from the teacher to the students. Students are encouraged to take greater ownership of their learning efforts and the teacher plays a supporting role as a facilitator and expert-modeller. Student-centered teaching empowers students to be inquiry-focused, ask questions, solve authentic problems, engage in dialectical argumentation, challenge misconceptions, verbalize their thinking and defend the cogency of their ideas. When compared with traditional modalities of learning, alternative methods of student-oriented teaching approaches have been consistently found to develop higher levels of conative, cognitive and affective abilities in learners, improve short-term mastery and long-term retention learning as well as facilitate applied understanding of conceptual knowledge.

	N	Mean	Std Deviation
Express	1980	22.46	4.68
Normal Academic	866	21.33	5.79
Normal Technical	382	20.90	6.24
Sec 1	1042	21.69	5.49
Sec 2	1015	22.20	5.38
Sec 3	840	21.89	4.93
Sec 4	331	22.35	4.69

Table 5. Dependency on Text Books

Data analysis findings reveal a pattern of significance differences in the instructional approaches and practices applied in normal technical, normal academic and express classrooms. Comparatively, learning activities in normal technical classes were found to be less teacher-centered than express and normal academic classes. In turn, instructional interactions in normal academic classes were deemed to be more teacher-oriented than express classes. Singapore's goal-driven education system attempts to engender flexibility combined with structured progression by offering variegated learning pathways in alignment with students' intellectual capabilities. Streaming as it is commonly known places students within the three different educational bands of normal technical, normal academic and express according to the overall scores attained by students at their primary school leaving examinations. This strategy of streaming students based upon academic excellence was primarily designed to create a learning milieu where students of similar levels and dispositions of intellectual competences can be grouped together and be provided with appropriate levels of instructional mediation aimed at educational success. The underpinning rationale behind the streaming policy is that when students are organized within classroom structures differentiated by distinctions in academic performances, greater opportunities for achieving curricular innovations and reforms is possible by finding the best fit between students' learning potential and instructional modalities.

As it is, the educational route provided by the normal technical stream emphasizes lesser on the theoretical aspects of academic study and instead focuses more on hands-on practice and industry collaborations. On the other hand, the express stream places premium on performing well in academic pursuits and scoring high in standardized exams. The normal academic stream offers an in-between pathway to learning achievement. Hence, the lesser reliance on teacher-centered learning methods of instruction in normal technical classrooms can be explained in that normal technical students have a lesser span of attention and have difficulties in remaining focused for prolonged periods during teacher-directed learning activities such as lectures and demonstrations. Instead these students need more active engagement through student-led experiential and exploratory learning activities. What is however surprising and inexplicable is the finding that normal academic students assessed their learning environments to be more teacher-centered than express students. This is at logical odds with the natural expectation that since normal academic programs of study are academically less rigorous than their express counterparts, normal academic learning environments ought to be more teacher-centered. This finding can either be attributed to random aberrations in data collection and analysis procedures or is an area that merits further research scrutiny for clarifications to be sought.

In analyzing the comparative data obtained from students' responses on the dimension of teacher-centeredness across the 4 secondary academic levels, a significantly noteworthy pattern of observations emerge. Save for the exception of results on Secondary 1 and 2 levels, the lower the academic level the stronger the feedback from students that the teaching tended to be more teacher-centered. A plausible explanation for this trend could be that teachers feel that upper secondary students due to possessing a higher level of cognitive and intellectual capabilities than lower secondary students need less structure and scaffolding in their learning progression. More opportunities for students to exercise self-directed and independent learning can be given to these students to allow them to regulate their own learning. On the other hand, lower secondary students need a larger measure of teacher guidance and monitoring and so instructional mechanisms such as teacher demonstrations, students' copying meticulous notes during lessons, teacher checking homework, teacher-led explanations of rules and definitions are widely practiced in their classrooms.

Student-centeredness of learning

Corresponding with the empirical findings established for the domain of teacher-centered prescriptive approaches to instructional delivery, combined analysis of students' responses to items associated with the dimension of student-centeredness of learning reveal that express students perceive their lessons to be less student-centric than normal academic and technical students. The results of data analysis on the student-centeredness of learning activities seek to reinforce as well as give greater credibility to the explanations constructed in the previous section on the teacher centeredness of teaching practices since the two scales are defined by a converse relationship. Since express students are seen as the most 'prized' intellectual assets of the school and school rankings are determined by the performances of these students in standardized exit level examinations, lesser learning autonomy and more teacher-directed coaching seems to have been embedded in curricular implementation.

On the other hand, the general perception of teachers and school management that since normal academic and technical students pose a lesser degree of 'threat' to lowering school standings in the nationwide ranking exercise, greater experimentation with more innovative student-centered teaching mechanisms in classrooms appears to have been explored. Many of the strategies adopted by teachers in normal academic and normal technical classrooms were geared towards peer-directed collaborative and project-based learning activities. These activities steer students away from habits of mechanically learning 'dry' concepts and instead focus on tapping prior learned experiences to be applied in problem solving contexts. This becomes particularly pertinent in the case of normal technical students who do not like to be taught to and prefer fun-filled activities that engender learning in less overt but nevertheless meaningful ways. And so the emphasis of normal academic and technical curricular delivery has been on a host of varied instructional strategies such as self-directed learning from worksheets or textbooks, working collaboratively on science projects, regular monitoring of peers' learning progress, student-driven active discussions, engagement with practical problem solving tasks and hands-on practice sessions. These educational outcomes-based approaches open up rich possibilities for structuring learning to be socio-cultural in orientation and offer epistemic opportunities for socially mediated knowledge co-construction. Designing and implementing an instructional framework that promotes synergistic, experiential and dialogic discourse in classrooms facilitates gradual empowerment of at-risk students to become more motivated and engaged in their learning development. In light of common stereotypes such as normal academic and technical students being academically less adept, teachers of these students seem to be adopting the right instructional methods in countering these biases and impressing upon these students that their contributions are appreciated and valued. However, there is a nagging feeling that more could be done at institution wide levels in making strategic shifts from grades obsessed cultures to promoting learning focused educational processes in express classrooms through fostering student-centered pedagogical innovations. If such a change in mindset can be achieved at management levels in schools, then it will percolate down to teachers who would feel the environment to be more risk-free and less threatening to explore new ways of teaching that allow students to be seen as partners in the learning journey and take responsibilities for their own skills development.

Nature of Science

Science attempts to examine, analyze and make sense of the constantly changing ways of the temporal world and its objects. It is based on proof-based evidence, testability, objectivity, empiricism and replicability. Science through its investigative practices and methods offers valuable means and modalities of better knowing the nature of what we see and observe. Science in its authentic form promises avenues for the continual quest for truth but denies ascribing absolutist or unalterable values to its findings. As new scientific insights unravel, previously held erroneous understandings may have to be revised or jettisoned. Scientific endeavors thus entail constantly evolving inductive processes aimed at unearthing new conceptual and epistemic meanings of the workings of this universe we habitat in. Science as a predictive tool enables us to better comprehend the complexities of the world around us and how it functions. However, some do mistakenly consider science to be infallible and objectify its axioms to be definitive. Science is exploratory and evidence-driven in progressive seeking deeper understandings of phenomena we experience but closer scrutiny will reveal that science is not without its biases and pitfalls. In attempting to investigate, understand, and make generalizations about the physical properties of the natural world and the interconnectedness of relationships governing universal existence misinterpretations and faulty inferences abound. In grasping the nature and practices of science we realize that science is fallible, changeable and emergent.

It was found that there was a significant difference in participant students' perceptions of the nature science. Amongst the secondary school students, express level students had a more valid sense of science and its character than normal level students. Express level students were better conscious of the fact that scientists are prone to committing mistakes and science knowledge gathering is not a static process. Comparatively, normal academic level students fared better than their normal technical counterparts in the cogency of their views on science. They acknowledged the fallibility and shortcomings of scientific inquiry since new 'truths' replace or refine old ones in the face of fresh evidence. This finding could be attributed to the longer curricular hours and greater importance assigned to the study of science and conduct of laboratory experimentations for express level students vis-à-vis normal level students. Having been exposed to longer periods of sustained scientific learning in school, express level students appear to have gained better appreciation of the realm of science and its hypotheses-oriented frameworks. These students were cognizant of scientific laws being revocable and the procedures of establishing 'factual truths' to be a continuously on-going activity.

Across the different levels of academic study, there were significant differences in students' perspectives on the nature of science. Secondary 4 students had more compelling and viable opinions on the structural attributes of science than secondary 1 and 2 students. The upper level students readily understood the realities of scientific pursuits and their inherent limitations as well as the need to accept the tenability of scientific principles in the present context but amenable to modifications in the future when new evidence is uncovered. This piece of finding is not very surprising considering that secondary education in Singapore is the real entry point into the intellectual world of methodic study of science. Hence students from the lower secondary levels tend to entertain notions of science that are inchoate and developmental. On the other hand, the secondary 4 students having undergone a longer period of rigorous training in the theories and methodologies of science were cognitively better equipped in their assessment of the value and legitimacy of science.

Attitude towards Science

Science has progressively enabled humans to have more empirical, comprehensive and reliable understandings of the physical world we live in and our interactions with this world. If Science is to have an applied relevance in our lives, it is important to better comprehend the theoretical foundations of Science and their associated usefulness in unlocking the intricacies of the physical realities that surround us. For this to happen a critical mindset characterized by a permanent willingness to want to develop and apply positive and scientific habits of mind within a wide configuration of social contexts. An analysis of the major goals for science education reveals consistency in the view that cultivation of positive attitudes toward science is crucial to the advancement of Science literacy proficiencies. According to the National Science Education Standards a scientifically literate person should distinguish and recognize expertise, pseudoscience, epistemic limitations, the temporal nature of knowledge and effective argumentation. One's desire to want to gain mastery in Science is inextricably influenced by his/her attitude, disposition and interest towards scientific pursuits and knowledge gathering. Science attitudes are directly tied to achievement and performance in Science.

It was found in this study that express students were more favourably inclined towards Science and its study than normal academic and technical students. Normal academic students had a greater interest in scientific endeavours than normal technical students. The learning of Science in school typically involves the conceptual understanding of a large base of content knowledge consisting of core and complex principles, theories, suppositions and axioms, often done through 'dry' and didactic modes of instructional delivery. This might have made Science classes less popular amongst the academically less inclined normal academic and technical students. On the other hand, express students due to their theoretical bent of mind would have better enjoyed the activities organized in the Science classrooms. The older upper secondary students showed healthier dispositions towards Science education that did their lower secondary peers. This could be ascribed to the matured upper secondary students having a more informed appreciation of Science and its strategic role in tandem with technological developments towards the continual enhancement of the quality of human life. Interestingly, the boys recorded a higher level of interest in scientific inquiry than the girls. This could be reasoned in light of the intrinsic character of scientific investigations that demands a hands-on approach involving time consuming and often laborious practical applications and laboratory experimentations. This could have had a dampening effect on girls' eagerness to want to learn Science as they might not have been comfortable handling the variety of equipment and devices needed to perform scientific analysis.

Dependency on textbook based resources analysis

Though initiatives have been undertaken in Singapore schools to encourage teachers to shift away from predominant reliance on textbooks to capitalizing on other knowledge materials, especially those of electronic formats, textbooks still tend to be the main knowledge sources in classrooms. Content in recommended textbooks continue to inform the structure, design and delivery of lesson plans. Curricular thematic organization closely follows the instructional sequencing recommended in textbooks. And so it was not surprising that students responded that science textbooks play a central role in a wide gamut of learning activities – ranging from textbooks being the principal resources for preparatory reading to studying everyday examples and working on calculation examples found in textbooks during class proceedings to using textbooks for completing follow-up /remediation assignments. However what was noteworthy from data analysis was the finding that teachers in express classes rely significantly more on textbooks as an essential component of teaching than those in normal academic and technical classes. This could be ascribed to the aversion to risk taking on the part of teachers responsible for express classes in moving away from the prevalent engagement with textbooks in classroom environments to exploring alternative resources since the traditional methods of instruction have harvested good grades by students in standardized examinations. The fear of not being able to meet the high expectations set for express students and the generally low threshold for performance failure of these students have deterred teachers from experimenting with non-traditional knowledge mediums. Teachers of express classes seem to feel that it is a safer option to 'walk the beaten track' of assigning high levels of importance to textbooks in defining and shaping instructional dynamics.

On the other hand, due to lesser degrees of pressure felt by normal academic and technical teachers in achieving pre-defined targets on students' performance grades there is greater flexibility in examining and appropriately using non-textbook based educational materials. No one or set of Science textbooks comprehensively cover all needed information or present the sum of all observations collected in relation to scientific phenomena. A broad variety of knowledge resources presenting different perspectives on Scientific issues need to be actively considered and recommended to students for their reading. Particularly, in light of the widespread proliferation of information rich electronic media, the pedagogical affordances of digital information cannot be downplayed and its judicious use in learning contexts given serious thought. The findings suggest that school management levels should make paradigmatic shifts in moving away from an educational culture that unduly places emphasis on grades as performance indicators to one that empowers teachers to focus on the learning process through leveraging different learning strategies and resources.

Interestingly, no significant differences were found in students' perceptions of the influence of textbook usage in curricular implementation across the four different academic levels of study.

Conclusion

Students' attitudes towards Science and its pedagogical treatment in class is dependent upon their prior experiences in interacting with scientific inquiry and their worldviews on the practical relevance of Science in the everyday world. Students' beliefs and viewpoints on Science is a critical motivational factor that influences their willingness to want to participate in scientific quests of empirical investigations and conceptual meaning making. This paper was an attempt to construct and present the perceptual profile of secondary school students in Singapore on how they looked upon Science and the instructional efficacy of the modalities employed by their teachers to deliver Science subject content matter. The findings of this study reveal that generally students were satisfied with the design and delivery of the Science curriculum and held valid notions of the character of Science. Interestingly, significant gender and academic stream based differences did emerge in analyzing students' responses to the different attitudinal measures specified in the survey instrumentation. In our discussions we have proffered explanations to deconstruct the plausible rationale behind these differences. Though the conclusions drawn in this study were reliably established based upon statistical methods of data analysis, the narrative explanations delineated to better understand the reasons behind these conclusions could potentially be delimiting due to their speculative and interpretive nature. However, this limitation serves well in opening the doors to carrying out further qualitative research studies in the future in validating these explanations or modifying them where need be to expand current scholarship on students' attitudes towards "Science-in-action".

Overall, we believe that the key findings of this study would play a pivotal role in Science education in Singapore by providing informed insights to teachers and policy makers in guiding their efforts at invigorating Science instruction through curricular innovations and enhancements. By appropriately leveraging upon active instructional strategies matching students' levels of intellectual curiosity and capabilities, students can be made aware of the strengths and shortcomings of Science and challenged to approach the learning of Science as a dynamic practice rather than a static entity.

References

[1]. **Ausubel, D. (2000).** *The acquisition and retention of knowledge a cognitive view.* Norwell, MA: Kluwer Academic Publishers

[2]. **Chiapetta, E. L., & Koballa, T. R. (2005).** *Science instruction in the middle and secondary schools*. Upper Saddle River, NJ: Merrill Prentice-Hall.

[3]. **Gardner, H. (1991).** *The unschooled mind: How children think and how schools should teach.* New York: Basic Books.

[4]. **Gunstone, R. F. & Mitchell, I. J. (1998).** Metacognition and conceptual change. In Mintzes, J.J., Wandersee, J.H. & Novak, J.D. (Eds.). *Teaching science for understanding: A human constructivist view.* San Diego, CA: Academic Press.

[5]. **Koballa, Jr., T. R., Crawley, F. E., & Shrigley, R. L. (1990).** A summary of science education-1988. *Science Education, 74 (3)*, 369-381.

[6]. **Lederman, N. (1992).** Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*, 331-359.

[7]. **Linn, M.C. (1992).** Science education reform: Building the research base. *Journal of Research in Science Teaching, 29*, 821-840.

[8]. **Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., & Chrostowski, S.J. (2004),** Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

[9]. **Mintzes J., Wandersee, J., & Novak, J. (2000).** *Assessing science understanding: A human constructivist view* (Rev. ed.). San Diego: Academic Press.

[10]. **Nakhleh, M. B. (1993).** Are our students conceptual thinkers or algorithmic problem solvers? Proceedings of Symposium: Lecture and Learning: Are they compatible? *Journal of Chemical Education, 70* (1), 52-55.

[11]. **Novak, J.D. (2002).** Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education, 86*(4), 548-571.

[12]. **Pushkin, D.B. (1998).** Post-formal thinking and science education: How and why do we understand concepts and solve problems? In J. Kinchella (Ed.), *Post-formal thinking: Questioning educational psychology and the education it supports*. New York: Garland Publishers.

[13]. **Roehler, L. & Cantlan, D. (1997).** Scaffolding: A powerful tool in social constructivist classrooms. In Hogan, K. & Pressley, M. (Eds.,. *Scaffolding student learning*. Cambridge, MA: Brookline Books.

[14]. **Schreiner C (2006)** *Exploring a ROSE-garden. Norwegian Youth's Orientations Towards Science - Seen as Signs of Late Modern Identities*. Doctoral thesis, University of Oslo, Norway.

[15]. **Schreiner C, Sjøberg S (2004)** Sowing the seeds of ROSE. Background, rationale, questionnaire development and data collection for ROSE (Relevance of Science Education) - a comparative study of students' views of science and science education. *Acta Didactica, 4*. Oslo, Norway: University of Oslo Department of Teacher Education and School Development.

[16]. Trowbridge, L. W., Bybee, R.W., & Powell, J.C. (2004). *Teaching secondary school science; Strategies for developing scientific literacy*, Upper Saddle River, NJ: Prentice Hall, Inc.

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